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Participatory Variety Selection of Improved Food Barley (Horde um vulgare L.) Varieties for Yield and Related Traits at Adiyo District, South Western Ethiopia

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Abstract

Food barley is a major staple cereal in Ethiopia, valued for its nutritional contribution, adaptability to diverse agro-ecologies, and role in household food security and income generation. Southwestern Ethiopia is a major barley-producing region; however, productivity remains low due to limited access to improved varieties, inadequate crop management, soil acidity, and disease pressure. This study aimed to identify high-yielding and well-adapted food barley varieties through participatory evaluation. Field experiments were conducted during the 2023 and 2024 cropping seasons in Adiyo District, Kaffa Zone. Ten improved barley varieties were tested using a mother–baby trial design. Six farmers hosted the mother trials as replications, while ten additional farmers managed the baby trials under their own conditions. Analysis of variance showed significant differences among varieties for most traits, except days to heading and spike length. Adoshe gave the highest grain yield (4975 kg ha^{-1}), followed by Jobera (4886 kg ha^{-1}), while Tiret (2532 kg ha^{-1}) and Abdane (2765 kg ha^{-1}) had the lowest yields. Farmer ranking, based on yield, maturity, tillering, disease response, spike length, and plant height, also identified Adoshe and Jobera as the best varieties. Both statistical results and farmer evaluations consistently identified Adoshe and Jobera as superior varieties. Therefore, these varieties are recommended for pre-extension demonstration and wider dissemination in the study area. Future research should focus on multi-location and multi-season evaluation to verify yield stability, assess resistance to emerging stresses, and enhance broader adaptation across similar agro-ecologies.

1. Introduction

Barley (*Hordeum vulgare* L.) is a self-pollinating, diploid cereal crop belonging to the Poaceae family and ranks fourth globally after wheat, maize, and rice. Its broad adaptation to diverse agro-ecological conditions, particularly highland and marginal environments, makes it an important crop for food security and resilience to climate variability. Globally, barley is used for human consumption, animal feed, and malting industries, reflecting its economic and nutritional value. In Ethiopia, barley is a major staple crop and an integral component of rural livelihoods, used for traditional foods, local beverages, livestock feed, and construction purposes. The country is also recognized as a center of origin and diversity for barley and is among the leading producers in Africa (FAOSTAT, 2021).

Barley productivity varies considerably across regions. The global average yield exceeds 3.0 t ha^{-1}, while in Africa it is about 2.0 t ha^{-1}, largely due to biotic and abiotic stresses. In Ethiopia, national productivity ranges from 2.1 to 2.3 t ha^{-1}, which remains below the global average (Central Statistical Agency, 2022). In southwestern Ethiopia, particularly in Kaffa Zone and Adiyo district, productivity is even lower, averaging 2.0–2.5 t ha^{-1} under farmers' conditions. This variation indicates a substantial yield gap between potential and actual production. Previous studies have shown that improved varieties and better management practices can significantly increase yields; however, adoption is constrained by limited access to technologies, weak extension systems, and socio-economic factors (Haile, M. et al., 2024).

Participatory varietal selection (PVS) has been widely promoted as an effective approach to improve adoption and productivity. Studies by Ceccarelli and Grando (2009) demonstrated that integrating farmers into the selection process enhances varietal adaptation and acceptance under diverse environments. Similarly, research findings indicate that PVS improves matching of varietal traits with farmers' preferences, leading to higher adoption rates and yield gains. Other empirical evidence also confirms that farmer-managed trials provide more realistic performance evaluation compared to researcher-managed conditions, especially in heterogeneous environments. Despite these advantages, the application of PVS in barley improvement remains limited in many parts of southwestern Ethiopia.

Barley production in the study area is constrained by several factors, including the lack of high-yielding and disease-resistant varieties, declining soil fertility, prevalence of diseases such as net blotch and scald, and poor agronomic practices. In addition, limited farmer participation in varietal evaluation has led to low adoption of improved technologies, as released varieties often fail to meet farmers' preferences and local production conditions. These constraints contribute to persistently low productivity despite the crop's importance in the farming system.

This highlights a clear research gap in the participatory evaluation of improved barley varieties under farmers' conditions in southwestern Ethiopia. Addressing this gap is essential to enhance productivity, ensure technology adoption, and support sustainable crop improvement. Therefore, the aim of this study is to evaluate the performance of promising food barley varieties under both researcher- and farmer-managed conditions, assess farmers' acceptance and preference for different varieties based on yield and related traits, and generate feedback on desirable characteristics to inform future barley breeding programs.

2. Materials and Methods

2.1 Description of the Study Area.

The field experiment was conducted during the 2023 and 2024 main cropping seasons in Adiyo District, located in the Kaffa Zone of the Southern Nations, Nationalities, and Peoples' Region (SNNPR), southwestern Ethiopia. The district is situated approximately 520 km southwest of Addis Ababa, the capital city of Ethiopia. Geographically, the study site is situated at 7°07'58" N latitude and 35°47'31" E longitude, at an altitude of 2221 m above sea level. The area is characterized by a humid agroecology with a unimodal rainfall pattern, typical of the main rainy season.

2.2 Experimental Materials and Design

The study evaluated ten improved crop varieties: Adoshe, HB-1965, HB-1966, HB-1493, Abdane, Biftu, Tiret, Gutaa, Jobera, and HB-1307 (used as a standard check). The experiment was conducted using a mother–baby trial approach to integrate both researcher-managed and farmer-managed evaluations.

The mother trials were conducted on six selected farmers' fields, with each farmer serving as a replication. In addition, baby trials were carried out on ten farmers' fields based on their willingness to participate, enabling broader assessment under farmer-managed conditions.

Each mother trial plot measured 3 m² (2.5 m in length and 1.2 m in width) and consisted of 15 rows spaced 0.20 m apart. A spacing of 0.50 m was maintained between adjacent plots. The crop was sown at a seed rate of 150 kg ha^{-1}. Fertilizers were applied at rates of 121 kg ha^{-1} NPS and 150 kg ha^{-1} urea in accordance with recommended agronomic practices.

2.3 Data Collected

From the mother trials, the following agronomic and phenological parameters were recorded: days to heading, days to physiological maturity, plant height, spike length, number of total tillers per plant, thousand seed weight, grain yield, and disease incidence.

In the baby trials, farmers evaluated the tested varieties using a preference ranking method based on their own selection criteria.

2.4 Statistical Analysis

Quantitative data obtained from the mother trials were subjected to analysis of variance (ANOVA) using SAS software. Treatment means were compared using the Least Significant Difference (LSD) test at a 5% probability level.

Categorical data were analyzed using the Chi-square test, while ranked data from farmers' evaluations were analyzed using matrix ranking procedures in accordance with standard statistical methods.

2.5 Ethics Approval and Consent to Participate

This participatory variety selection study involving human participants (farmers) was conducted in accordance with relevant institutional guidelines and national regulations for agricultural research in Ethiopia. Ethical approval for the study was obtained from the Research Ethics Review Committee of the Southwest Ethiopia Agricultural Research Institute (SWEARI), Ethiopia.

Before the establishment of the field experiments, all participating farmers were properly informed about the objectives, procedures, and expected benefits of the study. Participation was entirely voluntary, and informed consent was obtained from all participants prior to their involvement in the study.

All methods were carried out in accordance with relevant institutional guidelines and regulations.

3. Result and Discussion

3.1 Analysis of Variance (ANOVA).

The analysis of variance revealed the presence of statistically significant variability among the evaluated food barley varieties for several agronomic traits (Table 1). Specifically, highly significant differences ($P \leq 0.01$) were observed for days to maturity, plant height, thousand seed weight, and grain yield, while total tillers per plant showed significant variation at $P \leq 0.05$. In contrast, days to heading and spike length did not exhibit statistically significant differences among the tested varieties.

The existence of significant variation in key traits such as maturity period, plant height, and grain yield indicates substantial genetic diversity among the studied barley genotypes, suggesting the potential for effective selection and breeding. Similar findings have been reported by Ferede et al. (2020), who documented significant genotypic differences in barley for yield and yield-related traits under Ethiopian highland conditions. Likewise, Mohammadi et al. (2012) reported highly significant differences among barley genotypes for plant height and grain yield, emphasizing the role of genetic variability in crop improvement programs.

The non-significant differences observed for days to heading and spike length may indicate limited genetic variability for these traits among the tested varieties or strong environmental influence masking genotypic effects. This observation aligns with the findings of Hailu et al. (2016), who reported non-significant variation in heading date among improved barley cultivars grown under similar agro-ecological conditions.

For instance, Tadesse et al. (2018) observed significant variation in days to heading and spike length among barley genotypes. The discrepancy between these findings and the present study could be attributed to differences in genetic backgrounds of the materials used, environmental conditions, or genotype-by-environment interactions.

The significant differences detected for grain yield and its associated traits in the present study are consistent with reports by Ceccarelli and Grando (2009), who emphasized that yield variation in barley is strongly influenced by both genetic factors and environmental adaptability. On the other hand, some studies, such as Akcura et al. (2005), have reported non-significant differences in certain yield components under uniform environmental conditions, suggesting that reduced environmental variability may limit the expression of genetic differences.

Table 1. Analysis of variance for food barley varieties tested at Adiyo

Source of variation	DF	DH	DM	PH	SL	TTPP	TSW	GY
Treatment	9	13.43^{ns}	95.00**	93.11**	1.46^{ns}	11.78*	55.93**	3006770.11**
Replication	3	58.40^{ns}	446.76**	53.45^{ns}	7.96*	50.92**	9.06^{ns}	18600.52^{ns}
Error	27	20.83	8.76	18.04	1.94	4.25	9.89	287510.44
Total	39							

** = significant at (P≤0.05), ** = significant at (P≤ 0.01), DH = days to heading, DM = days to maturity, PH = plant height, SL = spike length, TTPP = total tillers per plant, TSW = thousand seed weight, GY = grain yield (kg ha-1).*

3.2 Mean Performance of Food Barley Varieties

The average performance of ten food barley varieties across seven agronomic traits is summarized in Table 2. The analysis revealed clear variation among the tested varieties, indicating the presence of useful genetic diversity.

Grain yield differed significantly among varieties (P ≤ 0.05). The highest grain yield was recorded from Adoshe (4975 kg ha⁻¹), followed closely by Jobera (4886 kg ha⁻¹). In contrast, the lowest yields were obtained from Tiret (2532 kg ha⁻¹) and Abdane (2765 kg ha⁻¹). These results suggest that Adoshe and Jobera have superior yield potential under the study conditions.

Differences in maturity were also observed. Tiret was the earliest maturing variety (113 days), while Biftu required the longest time to reach maturity (128 days). Early maturity is often advantageous in areas prone to terminal drought, as it allows crops to escape moisture stress. This finding agrees with the work of Bekele et al. (2019), who reported that early-maturing barley varieties perform better in moisture-limited environments.

Plant height showed significant variation among varieties. Guta (121.7 cm) and Tiret (121.6 cm) were the tallest, whereas Jobera (105.4 cm) was the shortest. Taller plants may contribute to higher biomass production but can also increase the risk of lodging. Conversely, shorter plants, such as Jobera, are often preferred in high-input systems due to better lodging resistance, as reported by Pržulj and Momčilović (2011).

Thousand seed weight (TSW), an important yield component, was highest in HB-1307 (46.76 g), followed by Adoshe (46.74 g) and Jobera (46.47 g). Tiret had the lowest TSW (34.27 g). Higher seed weight generally contributes to improved grain yield, which is consistent with findings by Baik and Ullrich (2008), who emphasized the importance of kernel weight in determining barley productivity.

Spike length and total tillers per plant:Jobera produced the highest number of tillers (15), which likely contributed to its high grain yield. This supports previous findings by Ceccarelli and Grando (2009), who noted that increased tillering capacity is positively associated with yield under favorable conditions.

However, some studies report contrasting results. For instance, Lakew et al. (1997) found that high tiller number does not always translate into higher yield due to competition among tillers for resources. This discrepancy may be explained by environmental differences, management practices, and genotype-by-environment interactions.

Table 2. Mean performance of food barley varieties for seven traits evaluated at Adiyo

Variety	DH	DM	PH	SL	TTPP	TSW	GY
Adoshe	72	118	120.8	18.55	14	46.74	4975.2
HB-1965	68	117	117.25	18.65	13	41.36	3359.7
HB-1966	71	125	115.1	18.7	11	40.94	3053
HB-1493	73	127	114.7	18.8	12	41.15	3132.6
Abdane	70	121	116.2	18.85	10	41.81	2765.9
Biftu	73	128	114.05	19.55	11	42.04	3088.3
Tiret	69	113	121.6	18.85	11	34.27	2532.9
Gutaa	71	118	121.7	17.8	11	42.36	3982.4
Jobera	69	121	105.4	19.95	15	46.47	4886.3
HB-1307	69	119	118.2	19.45	14	46.76	4233.5
LSD	6.62^{ns}	4.29**	6.16**	2.02^{ns}	2.99*	4.56**	777.95**
CV (%)	6.49	2.45	3.65	7.36	17.04	7.42	14.89
Mean	70.30	120.58	116.5	18.92	12.10	42.39	3600.98

DH = days to heading, DM = days to maturity, PH = plant height, SL = spike length, TTPP = total tillers per plant, TSW = thousand seed weight, GY = grain yield (kg ha-1), CV = Coefficient of variation

3.3 Farmers' Preference Ranking

Farmers' evaluations play a crucial role in identifying adaptable and acceptable varieties. In this study, 15 farmers (12 male and 3 female) participated in the preference ranking based on key traits such as grain yield, maturity, tillering ability, disease resistance, spike length, and plant height.

The direct matrix ranking (Table 3) showed that Adoshe ranked first (score = 70), followed by Jobera (score = 68). These varieties were highly preferred due to their high yield, good disease resistance, and desirable agronomic traits.

On the other hand, HB-1966 (score = 39) and Abdane (score = 41) were ranked lowest. Farmers identified these varieties as late maturing and more susceptible to diseases, making them less suitable for local conditions.

These findings are consistent with participatory varietal selection studies by Jalata, et al. (2023), which showed that farmers prioritize yield, disease resistance, and maturity when selecting barley varieties. However, some studies, such as Weltzien et al. (2019), highlight that farmers' preferences can vary

widely depending on socio-economic factors and local production systems. This variation explains why some varieties that perform well agronomically may not always be preferred by farmers.

Table 3. Direct matrix ranking evaluation of food barley varieties by group of farmers' (on field) at Adiyo (n=15)

Variety name	Ranking of selection criteria for each variety							
	Grain yield	Days to maturity	Total tillers	Disease resistance	Spike length	Plant height	Total score	Rank
	3(RW)	**2**(RW)	3(RW)	3(RW)	2(RW)	2(RW)		
Adoshe	5(15)	5(10)	4(12)	5(15)	4(8)	5(10)	70	1
HB-1965	3(9)	4(8)	3(9)	4(12)	4(8)	4(8)	54	5
HB-1966	2(6)	3(6)	2(6)	3(9)	3(6)	2(4)	39	10
HB-1493	3(9)	3(6)	3(9)	3(9)	4(8)	3(6)	47	6
Abdane	2(6)	2(4)	3(9)	3(9)	3(6)	3(6)	41	9
Biftu	2(6)	2(4)	3(9)	3(9)	4(8)	3(6)	42	8
Tiret	3(9)	4(8)	2(6)	3(9)	3(6)	3(6)	44	7
Gutaa	5(15)	4(8)	4(12)	4(12)	4(8)	4(8)	63	3
Jobera	5(15)	5(10)	4(12)	5(15)	4(8)	4(8)	68	2
HB-1307	4(12)	4(8)	4(12)	4(12)	5(10)	4(8)	62	4

number of participants =15 (male = 12, female = 3). Rating of performance of a variety for a selection criteria: 5 = excellent, 4 = very good, 3 = good, 2 = poor and 1= very poor. RW= Relative weight of a selection criteria: 3 = Very important, 2 = important and 1 = less important. The numbers in the parenthesis indicates the product of relative weight of the selection criterion and the performance of a variety given by farmers.

3.4 Farmers' Feedback from Baby Trial

Farmers' qualitative feedback (Table 4) further supported the ranking results.

Adoshe was highly appreciated for its high yield, strong tillering ability, disease resistance, early maturity, and uniform growth. Its only limitation was relatively shorter spike length.Jobera was also favored for its high yield, disease resistance, large spike size, and good tillering capacity. However, farmers noted its late maturity and short plant height, which may increase susceptibility to weed competition.

The standard check, HB-1307, was recognized for its high yield, large spike, and attractive grain characteristics. Despite these advantages, it was criticized for disease susceptibility and non-uniform

maturity.

These observations align with findings by Buli (2021), who reported that farmers value not only yield but also traits such as uniform maturity and disease resistance. However, contrasting evidence from Mulatu and Lakew (2011) suggests that improved varieties may sometimes lack stability across environments, which explain the mixed feedback for HB-1307.

Table 4. Participant farmers feedbacks about varieties from baby trial

Varieties	Positive qualities	Negative qualities
Adoshe	• High yielder • High tillering ability • Disease resistance • Early mature • Uniform in maturity • Attractive seed color and size	• Smaller spike length
Jobera	5. High yielder 6. Disease resistance 7. Uniform in maturity 8. Larger spike length 9. High tillering ability 10. Attractive seed color	• Late mature • Short in plant height (weed susceptible)
HB-1307 (standard check)	• High yielder • Larger spike length • Attractive seed color and size • High tillering ability	• Susceptible to disease • Not uniform maturity

4. Conclusion and Recommendations

This study revealed significant variation among the evaluated food barley varieties for most agronomic and yield-related traits under the agro-ecological conditions of Adiyo District, Southwestern Ethiopia. The combined use of field-based measurements and participatory farmer evaluations strengthened the identification of adaptable and farmer-preferred varieties. Among the tested genotypes, Adoshe and Jobera consistently showed superior grain yield performance and received the highest farmer preference scores. Adoshe combined high grain yield, relatively early maturity, and lower disease incidence, indicating strong adaptation to the study environment. Similarly, Jobera exhibited high yield potential and strong tillering capacity, although its relatively late maturity may reduce its suitability in areas prone to terminal moisture stress.

While the findings are promising, several factors should be considered when interpreting and applying the results more broadly. The study was conducted in a single district over two consecutive cropping seasons, which may not fully capture the environmental diversity and seasonal variability of major barley-growing areas in Ethiopia. In addition, although participatory evaluation improved the practical relevance of the study, the limited number of testing locations and participating farmers may affect the wider applicability of the results across different agro-ecological conditions. The study also focused primarily on agronomic performance and farmer preference, whereas important attributes such as grain quality, nutritional value, post-harvest characteristics, and economic profitability were not fully assessed.

Overall, the results indicate that Adoshe and Jobera have strong potential for production in the study area and similar highland environments. However, further validation under a wider range of environments is necessary before large-scale recommendation and dissemination. Future research should therefore emphasize multi-location and multi-season evaluations to assess yield stability, genotype × environment interactions, and adaptation under diverse production conditions. Additional studies integrating soil fertility management, grain quality analysis, economic feasibility, and climate-resilient production practices would further strengthen varietal recommendation strategies.

Declarations

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Conflicts of Interest/Competing interests

The authors declare that they have no competing interests.

Consent to Publish

Consent to Publish declaration: not applicable.

Data availability

The collected data and analyzed in this study can be obtained from the corresponding author upon reasonable request.

Autor contribution

All authors contributed equally to all aspects of this research. They have reviewed and approved the final manuscript, accept responsibility for its content, and confirm that it is original and not under consideration elsewhere.

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Figures

This picture shows over view of evaluated barley varieties on farmer sites.



Figure 1

Unnumbered image in the Result and Discussion section.

Farmers' Feedback from Baby Trial



Figure 2

Unnumbered image in the Result and Discussion section.